

Trans-NIH Tobacco and Nicotine Research Interest Group (TANRIG) Workshop
“What Makes a Cigarette a Cigarette?”

September 23, 2010, Rockville, MD

Bill Riley, from the National Heart, Lung and Blood Institute and co-chair of TANRIG, welcomed the group and explained that the aim of the meeting was to discuss the state of the science, including research gaps, related to the characteristics of cigarettes and the methodologies used to measure them. He noted that the aim at this preliminary stage was not to prioritize research questions or make recommendations, but to begin a dialogue among scientific experts working in related areas.

The agenda included two invited overview presentations followed by four discussion sessions focused on different topics and concluding remarks.

I. Overview Presentations

1. Dawit Bezabeh, “What Methodologies are Used to Assess Cigarettes?”

Dawit Bezabeh of the Alcohol and Tobacco Tax and Trade Bureau (TTB) gave the first overview presentation titled “What Methodologies are Used to Assess Cigarettes?” The presentation focused on definitions and procedures used by the TTB laboratory. The TTB belongs to the U.S. Department of the Treasury and is charged with collecting excise taxes and administering laws and regulations to protect revenue and the consumer. The laboratory, established in 2008, analyzes and classifies tobacco products. However, tax classification does not imply that products are “approved” for use or importation. There are currently eight product categories, including large and small cigars, large and small cigarettes, snuff, chewing tobacco, pipe tobacco and roll-your-own tobacco. The laboratory also works on method development to establish tests to distinguish between product categories.

A “cigarette” is defined as: (1) Any roll of tobacco wrapped in paper or in any substance not containing tobacco and (2) Any roll of tobacco wrapped in any substance containing tobacco which, because of its appearance, the type of tobacco used in the filler, or its packaging and labeling, is likely to be offered to, or purchased by, consumers as a cigarette described in (1). For example, cigarettes are distinguished from cigars based on the wrapper (cigar wrappers contain tobacco), the filler (cigars use air-cured tobacco rather than flue-cured), and the product’s appearance and packaging.

Different tax rates are applied to products in different categories. Manufacturers may modify products to fit into a particular category, and some products may be difficult to classify. For example, cigarillos, classified as large cigars but only slightly bigger than small cigars in appearance, represent a growing product category. Thus, it may be important to study how products evolve following changes in tax rates and classifications and to study products that are on the border between categories. Also, some novel nicotine products that do not contain tobacco are not classifiable under tobacco product categories.

2. Geoff Wayne, *“What Can We Learn from the Tobacco Industry about Defining the Tobacco Product?”*

Geoff Wayne of Harvard University gave an overview presentation titled “What Can We Learn from the Tobacco Industry about Defining the Tobacco Product?” The presentation material was based on internal tobacco industry documents that have been made publicly available as a result of litigation. At the start, it was noted that tobacco products are designed for consumers and that tobacco product characteristics cannot be understood without reference to their actual use. Industry documents demonstrate that the tobacco product design process includes knowledge of how the product will be used in the end.

Menthol cigarettes make up about one-fourth of the U.S. cigarette market, and the menthol category is distinct from the non-menthol market (i.e., smokers do not generally switch between menthol and non-menthol brands). Perception of menthol differs among smokers; menthol smokers describe the taste of menthol as mild and cool, while non-menthol smokers describe an unpleasant throat sensation when smoking menthol cigarettes. Additionally, younger smokers generally prefer a lower level of menthol to offset the irritating effects of tobacco smoke, while established menthol smokers prefer a stronger menthol taste.

Tobacco industry documents demonstrate that the tobacco industry has typically classified products by reference to the smoker, including patterns of use, perceived differences, and product preferences. For example, while the design of Marlboro changed significantly over time in its chemical and physical characteristics, the taste characteristics of the brand remained highly consistent. Thus, the product’s uniformity over time was based on perceived characteristics, not on physical properties. Similarly, differences between products are defined by reference to the smokers’ perceptions and behavior (such as whether they feel they need to work too hard to inhale a sufficient volume of smoke).

While some basic characteristics appear to be common to all cigarettes (contains tobacco, contains nicotine, relies on inhaled delivery), cigarettes are also designed to match the wants and expectations of users, to allow users to control delivery, and to support continued use.

During the discussion, it was suggested that cigarettes are designed in terms of purchasability rather than consumer acceptability or preference. That is, the tobacco industry’s strategy is not to maximize the flavors or characteristics that consumers like, but to produce a product that will be used consistently over time. Added flavors and other characteristics help to distinguish particular brands and drive consumer preferences within a diverse market, but these choices likely do not play a substantial role in maintaining smoking behavior. Thus, it is important to focus on those characteristics that drive smoking (and quitting) behavior, such as nicotine delivery, rather than the many characteristics that may simply serve to distinguish particular brands in a diverse marketplace.

II. Discussion Sessions

Topic 1: What are the important physical and design characteristics of a cigarette? How are they measured?

Cigarettes are typically constructed using one of two main types of cigarette tobacco blends: Virginia blend (predominantly bright leaf tobacco) or American blend (contains a mixture of bright leaf, burley, and Oriental tobaccos). Cigarette filler often contains reconstituted tobacco sheet, tobacco plant stems and ribs, and possibly other foreign content. Typically, blend analysis is done by manual separation using a microscope and forceps to physically separate each shred of tobacco in different piles and weighing the resulting separated tobacco types individually. The development of methods to selectively measure characteristic chemical markers for each tobacco component would be preferable to manual separation (visual inspection, etc.) for tobacco type. Some work has been developed using rutin and chlorogenic acid content, but this line of research needs further refinement. Stems are added to the filler for a variety of reasons, not just as a cost-saving means to add bulk. At present, stem content is done by visual inspection and physical separation. Various semi-quantitative methods such as the “float test” are available to examine whether or not particular filler contains reconstituted tobacco or expanded tobacco, but this is a destructive separation technique. Further work is needed to automate analysis.

Other important physical characteristics of the tobacco filler are cut width, moisture content, tobacco mass, and filler pH. Cut width can be determined by mechanical means, by essentially filtering the tobacco through wire screens or sieves with different mesh sizes. However, tobacco shreds are fairly fragile. Therefore, by separating them, they could break into smaller pieces, changing the size distribution during the measurement process. Other methods for examining cut width, including visual inspection, are more tedious. The simplest method to determine moisture content (volatiles content) is through gravimetric analysis. Unfortunately, other volatile constituents, in addition to water, are lost during heating. There are other routine analytical chemistry methods that are more selective for water content. Total tobacco filler mass can easily be determined using an analytical balance. The simplest method for measuring tobacco filler pH would be to use a conventional pH meter.

Cigarette tobacco filler often contains additives such as humectants, flavors, and sugars. Measures currently exist based on GC/MS or LC/MS techniques via many sources including ISO methods, CORESTA methods, FDA methods, TTB methods, and CDC methods. Work is needed to ensure applicable and validated methods are in place. The pH of the filler is important as this could influence the delivery of nicotine.

Several physical characteristics of a cigarette rod—including tobacco rod column and filter length (ruler), circumference (caliper), tobacco density/firmness (balance/ruler), pressure drop/void fraction (related to cut width, packing density, etc.), and end density—are important features that influence constituent delivery, and many can be measured by conventional means. At present, there appear to be no common analytical tools outside the industry for easily measuring end density or linear mass density of tobacco. Such measurements can be done manually by cutting the rod in segments, which are weighed, and then by using the rod diameter, circumference, and segment length, to determine the linear tobacco gradient. Methods for

determining wrapper properties (porosity) and wrapper constituents (paper, recon, leaf, etc.) are lacking in terms of automation. Those that exist are more qualitative than quantitative. Additives to paper can be examined by standard means (AA, ICP/MS, ion chromatography). Such additives are often used to reduce appearance of sidestream smoke, make ash look white (to increase appeal), or for burn rate modifiers (higher burn rate means fewer puffs under machine smoking conditions).

Cigarette filter type is a key characteristic of product design. Cellulose acetate, polyester (visual inspection), or paper can be used in the construction of modern filters. Some filters contain charcoal for improved filtration efficiency of the more volatile smoke constituents. Research is needed to expedite the determination of the filter type, efficiency, and additives to the filters. Some physical filter parameters such as filter length (ruler) and overwrap (when applicable since not every cigarette has a filter overwrap paper section) are easily measured using manual means.

Under a standard smoking machine, filter ventilation (amount, rows, location) plays a key role in mainstream smoke constituent delivery. The presence of filter vent holes is readily made through visual inspection or low-power microscopy. Standard equipment exists to determine the amount of filter ventilation. The burn characteristics of cigarettes influence the delivery of tar, nicotine, and carbon monoxide. Related variables useful for the classification of performance include static burn rate and puff count.

There are several areas that could benefit from improvements in technology. One is a means to determine elasticity of the product. This is important because there are design features that, if they were changed, would limit the elasticity of the product so that people are more limited in their ability to alter their target dose. For example, increase resistance to draw (RTD) would limit a smoker's ability to achieve much higher dosing. However, factors that limit elasticity could have unintended consequences if a smoker was able to alter the product in some manner, such as removing the filter, to increase the dosing level.

Topic 2: What ingredients may impact smoke chemistry and smoker acceptance?

General disclaimer: In contrast with the physical and design characteristics of cigarettes, which can be measured in laboratories outside of the tobacco industry, most of the available information on the impact of additives on smoke chemistry and smoker acceptance comes from formerly internal tobacco industry documents. Investigative studies of additives are limited by technical challenges, such as the experimentally manipulating the presence or absence of an additive in a tobacco product, as well as ethical and practical concerns in testing the effects of nonstandard cigarette use by humans. Our understanding of which industry findings on additives was incorporated into commercial products is incomplete.

Additives represent 6–10% of a typical U.S. blended cigarette by weight. The relative percentages of different tobacco components (e.g., reconstituted tobacco) influence the type and amount of additives used. The two main categories of additives are casings (predominantly sugars) and top dressing (flavorants).

Casing is typically a mixture of sugars, humectants, cocoa, and licorice. However, casing can include dozens of individual chemicals and chemical mixtures such as wine and fruit juice concentrates. Casing is applied to the tobacco in either a spray or dip application. It can be applied to the total tobacco blend or selectively such as to burley and Maryland tobaccos. The stated purpose of casing is to decrease the strength and harshness of smoke. It blends the irritant properties of smoke with other smoke sensations to make the degree of irritation and other sensations acceptable to the smoker. Casing can modify the taste of smoke by adding other flavor aspects (e.g., sweetness) that further mask irritating sensations. Casing helps retain moisture in the tobacco so the product doesn't dry out.

Top dressing can contain a wide range of synthetic and natural chemicals and chemical mixtures, including tobacco extracts, flavors such as vanillin or fruit flavors, and herbs and essential oils. Top dressing is commonly a spray application in alcohol but can also be incorporated in the casing. Top dressing fortifies or alters tobacco smoke taste or aroma. Top dressing can restore some of the quality aspects missing from an inferior grade of tobacco. Unlike casing, top dressing may also be added to the filter, paper, and packaging.

Other types of additives can be added to non-tobacco components of the cigarette or the cigarette packaging. These include burn rate controllers in the paper, adhesives, flavor release agents, film-forming agents, and ash modifiers. Some of these additives may reduce secondhand smoke visibility or irritation without reducing smoke emissions.

Promising research questions based on reports in previously internal tobacco industry documents include:

- Which additives make a cigarette easier to smoke, for example, which ease inhalation? Examples of additives that are reported to ease inhalation are cocoa/chocolate (theobromine and caffeine) and licorice (glycyrrhizin).
- Which additives influence nicotine pharmacokinetics? An example is levulinic acid (as a salt), which is reported to enhance the binding of nicotine to neurons that ordinarily would be unresponsive to nicotine.
- Which additives are pharmacologically active and could partially or completely substitute for nicotine? Menthol and vanillin are examples of additives reported to measurably change brain activity (P₁-N₂ EEG amplitudes).
- Which additives are the largest contributors to harmful and potentially harmful chemicals in smoke? Sugars form aldehydes (e.g., formaldehyde, acetaldehyde) when burnt. Studies in rats indicate that nicotine and acetaldehyde work together to produce greater addictive effects.

References

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Topic 3: How do cigarette design and ingredients impact the smokers' perception of the product and alter the way the product is used?

Topic 3 focused on how the design and characteristics of cigarettes impact smokers' subjective perceptions of the product and, in turn, how they use it. It was noted that while there are some common basic features of cigarettes (such as tobacco, nicotine, and inhaled delivery), internal tobacco company studies, as described in Geoff Wayne's presentation, have also relied on consumer response and behavior to define the product. One important question is to what extent subjective product characteristics drive product use (i.e., initiation and cessation) versus brand switching and choice? Consumer perception and response may have especially important public health implications to the extent that they impact cigarette-use behavior (i.e., increased or decreased cessation). Thus, it is important to identify those consumer perception characteristics that may impact cessation (as opposed to solely driving brand choice).

A suggestion was made that the characteristics of cigarettes that vary widely across brands may be more relevant to consumer perception and individual preferences while those characteristics that are similar across brands may be more fundamental properties of the cigarette.

Andrew Strasser of the University of Pennsylvania briefly described a current research project involving the Quest cigarette. In a month-long protocol, smokers switched to Quest cigarettes with progressively lower levels of nicotine. As they moved to cigarettes with 0.6 mg and 0.3 mg of nicotine they increased puff volume and cigarettes consumed per day, but at the lowest level of 0.05 mg, their efforts to compensate seemed to drop. Smokers found the 0.6 mg and 0.3 mg versions of Quest to be acceptable, though they did not like them as much as their usual brand. At the 0.05 level, they reported being very unhappy with the product. In another study, Strasser and colleagues looked at vent-blocking behavior in Marlboro Light smokers. The majority of smokers were aware of the presence of the vent holes, but all claimed that they did not block them (even though about 40% blocked the holes without being aware of it).

Richard O'Connor of the Roswell Park Cancer Institute also described a small study on vent-blocking behavior in smokers of "ultra light" brands. The investigators showed subjects the vent holes and explained the effects of blocking them, but subjects who had blocked vent holes at the

start of the study did not change their behavior despite being made aware of it. The study suggests that such smoking behaviors are automatic and unlikely to be changed by education or information.

One point that emerged from the discussion was the complexity of the interaction between physical cigarette design and product packaging and branding. Consumer perceptions of the product may be driven just as much by the branding, which is highly personal, as by physical characteristics of the product.

Some additional points raised during the discussion included the following:

- Are there ways to make cigarettes less attractive either by modifying the product or changing the packaging? Some smokers do not like non-ventilated or unfiltered cigarettes, for example. Additionally, graphic warning labels or plain packaging may deter smokers or reduce the effectiveness of branding.
- It may be important to study how the product is marketed both through advertising campaigns and at the point of sale. It was observed that Quest cigarettes were marketed as a method for stepping down nicotine intake, but that convenience stores routinely carried only the higher nicotine content versions.
- Relying on self-report of perceived differences between products has substantial limitations. There is a need to develop objective measures for consumer response to product characteristics and determine subtle differences. For example, the tobacco industry has studied consumer perception with more complex models and objective measures (such as EEG) in addition to self-report.
- Comparative product tests used in other arenas of consumer research (such as a triangle test comparing three products) should be further developed for use in tobacco product studies.
- Surveys and ongoing studies with tobacco users should collect brand and sub-brand specific information.
- A better understanding is needed of cigarette features that have a significant influence on smoking behavior. While the impact of venting has been studied, little is known about what happens with variation in other physical properties of the cigarette.

Topic 4: What cigarette design would minimize the adverse impact on smokers and nonsmokers?

The goal of minimizing the impact of cigarette smoking is a multidimensional problem. It will likely take a multipronged effort targeting cigarette design itself and understanding who initiates use and why by understanding the societal and environmental factors—including acceptability, cost, marketing, family and peer influences—that all contribute to smoking uptake.

A variety of physical parameters, including amount of tobacco, its nicotine content, length, circumference, filter length, ventilation, all influence product acceptance. The influence of these factors is not static, products can and do change over time, and people continue to accept the product.

The following questions were discussed:

What are the key design characteristics that can alter user behavior long term?

- Changes in nicotine content. Reduced nicotine content has been proposed as one solution to make cigarettes less attractive or addicting. However, some important questions remain to be addressed: Can a product be made unacceptable by reducing nicotine content? How would such a product be used in practice (i.e., might users supplement nicotine by other using products such as the patch)? What would be the effects of increasing nicotine content? Do we have to worry about health consequences given the stimulant effects of nicotine?
- The tobacco industry has focused on ventilation and reducing machine-measured tar, which has not had a beneficial impact on health. Cigarettes that are very heavily ventilated and with very low tar ratings may be less acceptable if smokers cannot draw enough nicotine.
- Ventilation. If filter ventilation is banned will that influence uptake? Has focusing on carbon monoxide content had any public health benefit?

In terms of harm reduction products, will marketing products, such as smokeless tobacco products, alter consumer perception? There are some emerging research findings that can help shape our thinking:

- Some novel tobacco products have low nicotine levels, and therefore consumers don't appear to like them as much. Those who are using the product may be increasing the number of cigarettes they smoke or changing the way in which they smoke it, thus increasing their exposure levels.
- Often these novel products are marketed or used as an alternative to smoking in areas where smoking is prohibited (e.g., airplanes, public transportation, the work place). Thus, one concern is that they may have a net adverse impact by supporting ongoing nicotine addiction and impeding cessation.
- Caution should be used in drawing conclusions about claims of lower cancer rates in countries with high snus use. Sweden has lower smoking prevalence (and less lung cancer) compared with other European countries. However, the lower smoking prevalence is not necessarily related to snus use, as other tobacco control interventions, such as early use of warning labels and greater treatment options, may be responsible for reducing smoking prevalence in Sweden.

What do we know about the safety profile of alternative products?

- So far no modified tobacco product has been shown to be free of risk.
- Claims of reduced risk can be undermined by product manipulation (e.g., manipulate ventilation). Also, it is important to be aware of how the product is used in practice and whether it is used in combination with others.
- What would be the effect of banning vents? Does that need to be coupled with lowering tar and nicotine? It is a feasible study, but for how long? Twenty-plus years?

Other critical questions:

- Is there a nicotine threshold, such that cigarettes containing doses below that will not produce dependence in most individuals?
- What would be the unintended consequences of reduced nicotine? Would we see a rise in dual use of tobacco products, such as reduced nicotine cigarettes with oral tobacco or small cigars, and how would this affect exposure to toxicants?
- If nicotine reduction is attempted, do we have the monitoring systems in place to understand the population-level impact of change?

Reference

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III. Final Discussion: Integration of Topics

A brief discussion at the end of the day raised some additional points and issues for consideration:

- Smoking behavior changes over time, not just in response to changes in the product, but also in response to new policies and other environmental factors, such as pricing and smoke-free policies. Adult smokers are smoking fewer cigarettes per day on average than in the past, but they may be smoking them differently. Thus, it is important not to solely study the product itself, but also how it is used and the surrounding policy context.
- In studying cigarettes, it is also important to pay attention to other smoked products, like cigarillos, as changes in pricing or marketing may have impacts across categories. The variety of tobacco products (including roll-your-own and new oral tobacco products) also poses a challenge for product classification and measurement.
- Cigarettes are complex and highly engineered products. Given limited resources, scientific research should focus on key elements of product design (such as nicotine delivery) rather than attempting to measure all constituents or design features.
- It is important to consider the potential unexpected consequences of interventions with the tobacco product. For example, the impact of a change in the cigarette may be different if pursued gradually over time than if a dramatic change is made abruptly.
- Attention to the relationship between product characteristics and smoking behavior is needed. While some characteristics may influence consumer preferences in a diverse marketplace, in public health terms it is important to understand the characteristics that influence smoking behavior, particularly initiation and cessation.